

12. On Skulls of Oxen from the Roman Military Station at Newstead, Melrose. By J. C. EWART, M.D., F.R.S., F.Z.S.*

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(Text-figures 63-91.)

Professor Marcellin Boule, in his recent work on the Grotto of Grimaldi †, states that Cuvier, Rüttimeyer, Nehring, Gaudry, Boyd Dawkins, Duerst, and other naturalists who have studied the Quaternary Bovidæ have regarded the Urus (*Bos taurus primigenius*) as identical with our modern *Bos taurus*, of which it was probably the ancestor, and from which it differed only by its greater size.

Though many naturalists since the days of Cuvier have directed their attention to the history of Domestic Cattle, the last word has not yet been said about their origin, hence in dealing with the remains of cattle from the Roman Military Station at Newstead, Melrose, the investigator must still bear in mind that a final answer has not yet been given to the question—Are modern European cattle descended from the Urus, *Bos taurus primigenius*? When discussing the origin of British cattle Prof. Hughes remarks: “Cæsar mentions that there were large herds of domesticated cattle in Britain, and we know from numerous excavations into Roman and Roman-British rubbish-pits that these belonged not to the Urus but to *Bos longifrons*. This, then, is the native breed with which we must start in all our speculations as to the origin and development of British oxen. The Romans found that breed here and no other.”

Writing about the Celtic Shorthorn (*Bos longifrons* Owen, *Bos brachyceros* Rüttimeyer) Mr. Lydekker says, “It is, and can be, nothing but a variety of *Bos taurus*” derived from the wild Urus at a very remote epoch—“the occurrence of remains of an apparently similar breed in the prehistoric lake-dwellings of Switzerland suggests that the breed may have been established prior to the separation of Britain from the Continent” ‡.

Bos frontosus Nilsson, Lydekker also regards as a variety of the Urus, and as there was no other primitive Wild Ox in Europe, and an Eastern derivation being in the highest degree improbable, Lydekker says that all the domesticated breeds of European cattle must trace their ultimate ancestry to *Bos primigenius*. While satisfied that the Domestic Cattle of Europe are descended from *Bos primigenius*, Lydekker thinks it is quite probable that the origin of the humped cattle of India (*Bos indicus*) may be, at least in part, different.

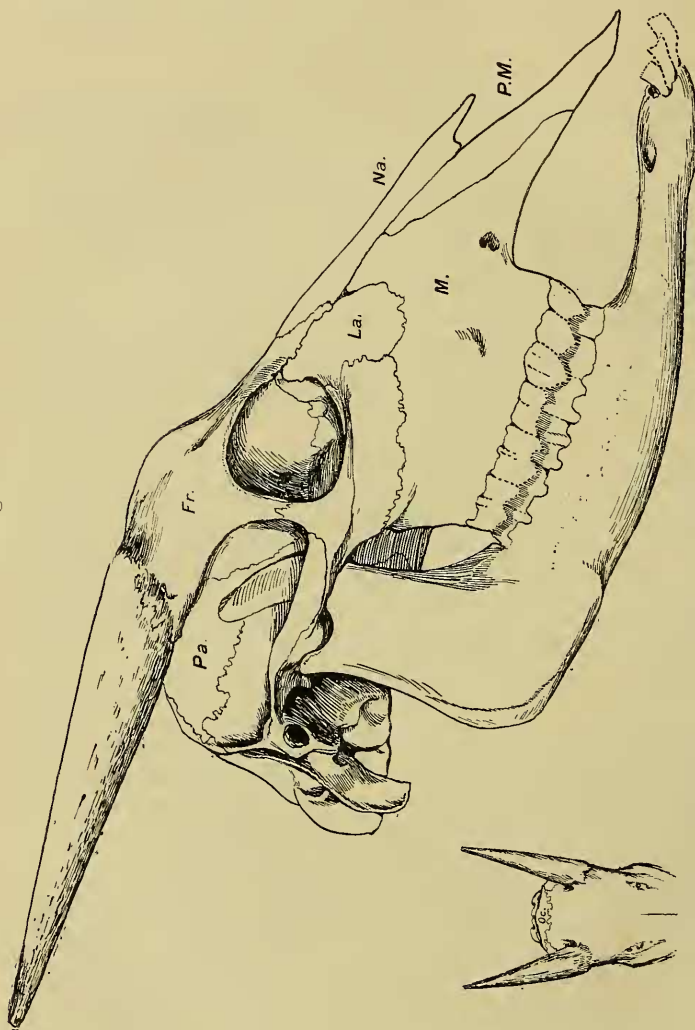
* The author is indebted to Mr. James Curle, Priorwood, Melrose, for the use of the Oxen skulls found at Newstead.

† ‘Les Grottes de Grimaldi,’ tome i. fascicule iii., 1910.

‡ ‘Wild Oxen, Sheep, and Goats,’ p. 18, 1898.

Though Professor Fairfield Osborn thinks that the Domestic Ox, instead of being a direct descendant of *Bos primigenius*, is a descendant of *Bos trochoceros* of the Italian Pleistocene, he differs

Text-fig. 63.

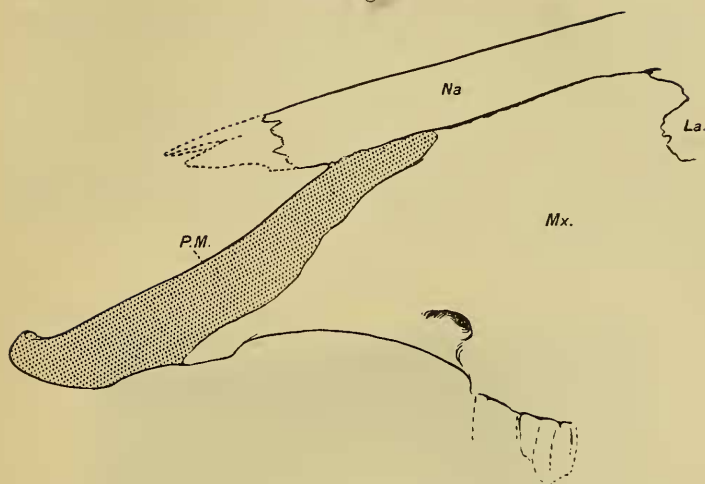


Skull of the Anoa (*Bos depressicornis*), in which the premaxillæ (*P.M.*) extend well upwards between the maxillæ (*M.*) and nasals (*Na.*). The horns occupy nearly the same position as in Antelopes. From a skull in the Royal Scottish Museum.

in no essential point from Lydekker, and, like Lydekker, believes British Shorthorn Cattle are descended from an indigenous Occidental race domesticated in Europe by the Neoliths*. A somewhat different view is taken by Prof. Boyd Dawkins, who

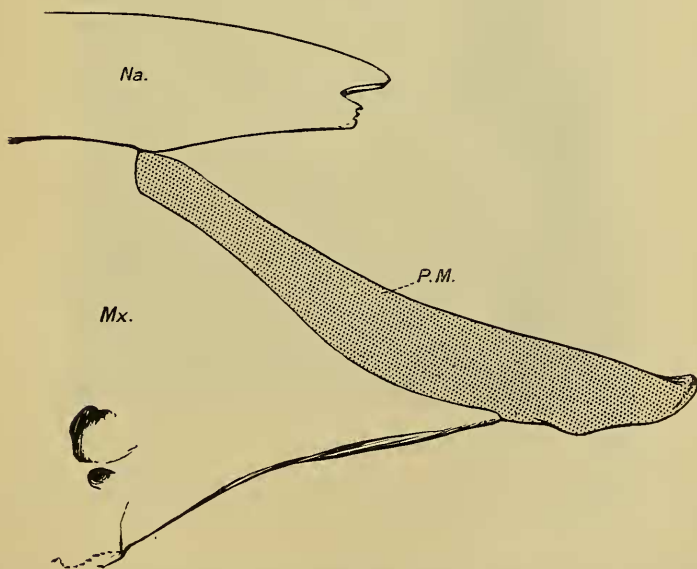
* Osborn, 'The Age of Mammals,' 1910.

Text-fig. 64.



Front part of the skull of a Buffalo (*Bos bubalus*).
The premaxillæ (*P.M.*), as in the Anoa, extend upwards between the maxillæ and nasals.

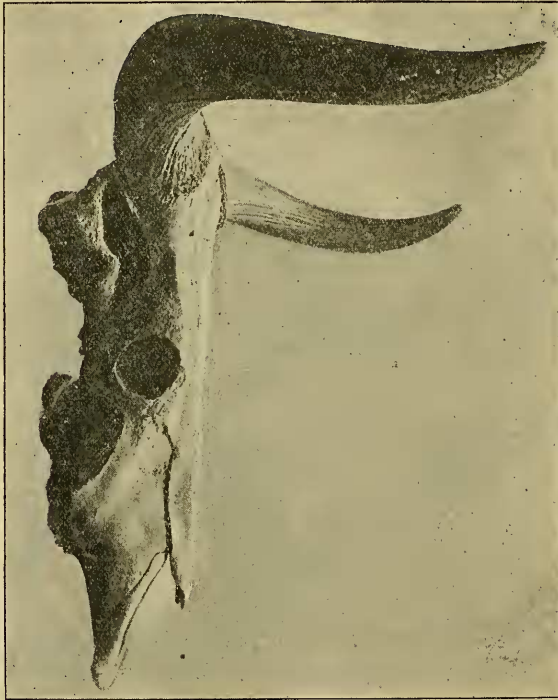
Text-fig. 65.



Front part of skull of the Urus (*Bos primigenius*).
In this skull the premaxillæ are only slightly connected with the nasals, but in a skull in the British Museum the premaxillæ extend nearly as far upwards between the maxillæ and nasals as in the Buffalo (text-fig. 64).

says: "It is clear the domestic animals were not domesticated in Europe, but that they had already been under the care of Man probably for long ages in some other region. The Turf-Hog, the Celtic Shorthorn, the Sheep, and the Goat have been domesticated in the countries in which their wild ancestors were captured by the hunter in Central Asia. To this region also belong the Jackal, the Wild Boar, and the Wild Horse, and in ancient times the Urus. It is therefore probable that all these domestic animals came into Europe with their masters from the south-east—from the Central plateau of Asia—the ancient home of all the present European peoples."

Text-fig. 66.



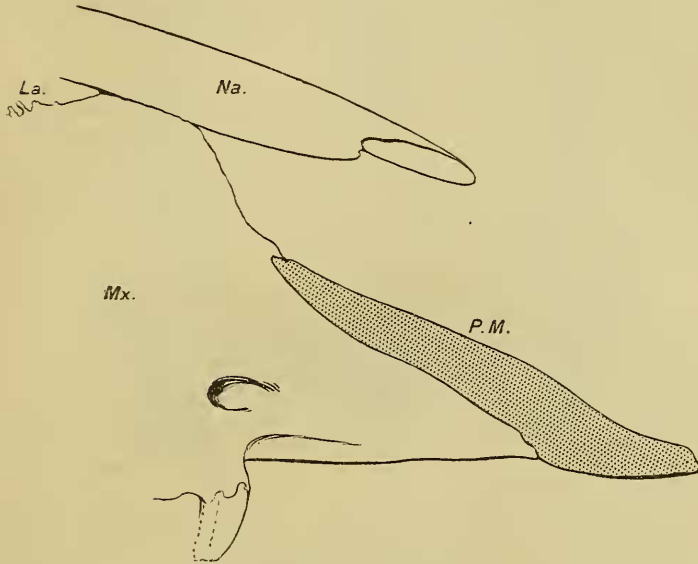
Skull of a Urus in the Anatomical Museum, University of Edinburgh.

The premaxilla has only a slight connection with the nasal, the forehead is flat, the temporal fossa is closed behind, and the horn-cores curve forwards at nearly a right angle to the forehead.

Of Continental zoologists, Prof. Duerst has for some years been directing most attention to the origin of domestic animals. In his report on the Animal Remains found in Turkestan by the

Pumpelly Expedition, Duerst says: "My recent studies on fossil remains of the bovines of the Indian Pleistocene have shown

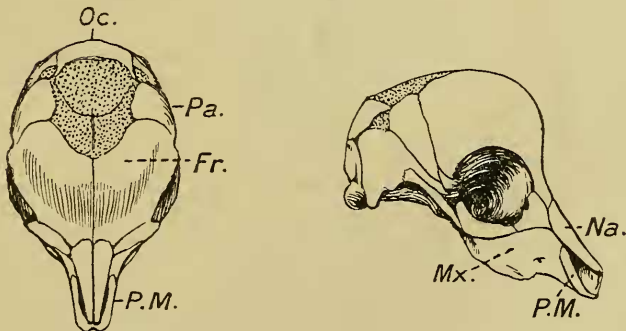
Text-fig. 67.



Front part of skull of American Bison.

The premaxillæ are short and far removed from the nasals.
From a skull in the Anatomical Museum, University of Edinburgh.

Text-fig. 68.



Front and side views of the skull of a young fetal Ox. Nat. size.

The premaxillæ (*P.M.*) reach the nasals (*Na.*), the frontals (*Fr.*) extend nearly as far backwards as in the adult Anoa, and there is a large gap between the frontals (*Fr.*), parietals (*Pa.*), and supra-occipital (*Oc.*).

me that the Indian (Narbada and Siwaliks) and China Taurina are the exact equivalents of the European Urus (*Bos primigenius* Bojanus), excepting some very slight variations produced by different geographical and local influences, so that the *Bos namadicus* Falconer and Cautley would represent the European Urus for the Asiatic Continent, especially the North Indian mountains and their neighbourhood”*.

In recapitulating the results of his studies of the bovids of Anau, Duerst says:—“In the lower layers of period Ia from — 24 feet upwards there occur the remains of a wild *Bos namadicus* Falconer and Cautley. During period Ib there originates from this wild form a domesticated bovid, large and stately, provided with long horns. Judging from the measurements of the preserved bones this is absolutely the same Ox that was possessed by the Ancient Egyptians.

“In the period II the size of the animal seems to have somewhat diminished, unless possibly a smaller bovid reached Anau with the other newly imported domestic animals. It is, however, possible that this form of cattle of the culture II originated in a decline of the cattle-breeding of the later Anau-li; as, indeed, the originally large long-horned Ox of the early Babylonians had already become small and short-horned in Assyrian times, and to-day, after a relatively shorter interval, shows a tendency to become hornless” †.

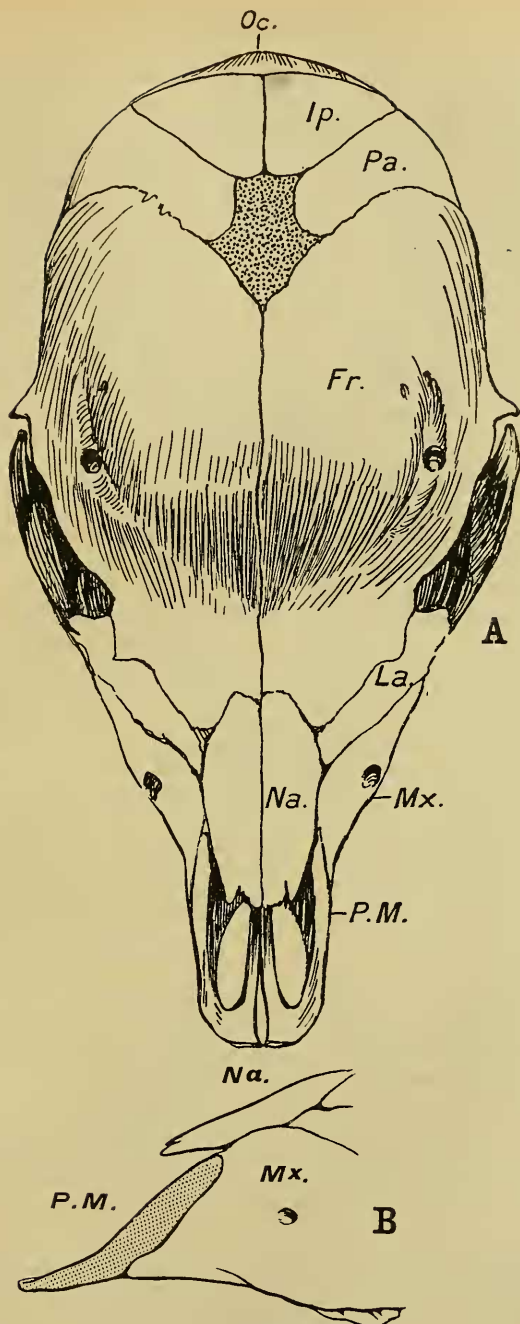
Duerst goes on to say:—“The first remains of the long-horned breed (*Bos taurus macroceros*) belong at Anau about 8000 B.C. We find the same animal again about 3000 to 4000 B.C. in Babylonia and Egypt. At about 6000 B.C., however, we find that the large long-horned animal of Anau has become small and small-boned and has developed into a short-horned breed (*Bos brachyceros*) ‡. Therefore all who do not believe in an autochthonous domestication of the animals for each separate culture-sphere must admit that the original large and stately long-horned Ox of Anau was spread by tribal migrations before 6000 B.C. to Persia and Mesopotamia and into Egypt and Central Africa on the one hand and on the other to India and Eastern Asia, where according to Chinese accounts it arrived in 3468 B.C.

“Did the migration of the West occur only after the small breed had become established, *i. e.* about 6000 B.C., or even between 6000 and 7000 B.C. when the turbary sheep had formed? To this question we have as yet no answer. We must, however, add that it was not in Anau alone that through unfavourable conditions of life the originally large and stately Ox was changed into the stunted and short-horned form (*Bos taurus brachyceros*). The same change took place in Mesopotamia, as one may easily perceive in comparing the long-horned cattle of Chaldean or Sumero-Accadian times with the Assyrian small short-horned and the

* ‘Animal Remains from Excavations at Anau,’ Carnegie Institution of Washington, p. 361.

† Duerst, *op. cit.* p. 369.

‡ *Bos brachyceros* is the same as *Bos longifrons*.



- A.**—Front view of a fetal Ox skull about the fifth month. The premaxillæ (*P.M.*) reach the nasals (*Na.*), the frontals (*Fr.*) are long, the parietals (*Pa.*) narrow, and the interparietals (*Ip.*) lie between the parietals and supra-occipital. Nat. size.
- B.**—Front part of same skull, to show relation of premaxillæ to nasals. Nat. size.

modern loose and short-horned or hornless cattle. There is, therefore, no reason for rejecting the assumption or hypothesis that the Ox of Anau, which about 7000 B.C. was undergoing this change of form, finally reached Central Europe, after its migration through Southern Russia and Eastern Europe, in the stunted form of *Bos taurus brachyceros*,* *i. e.* in the small Celtic Shorthorn generally known in England as *Bos longifrons*.

If the conclusions arrived at by Duerst and others are justified, it follows (1) that all the modern domestic cattle—the humped breeds of India and Africa as well as the European breeds—are derived either from the Urus of Europe (*Bos taurus primigenius*) or its reputed near relative the Urus of Asia (*Bos namadicus*), or are a blend of varieties or races of these two species; and (2) that modern British breeds have been formed by crossing the Celtic Shorthorn (*Bos longifrons vel brachyceros*)—the small domesticated race widely distributed over Britain in pre-Roman times—with Continental breeds (including short-horned as well as long-horned varieties) introduced since the Roman invasion. Are these conclusions supported by the remains of cattle from the border-forest occupied by Roman auxiliaries during the first and second centuries of the present era?

Prof. Boule, in his recent work on the Grimaldi fossils, says the genus *Bos* (which includes the most specialized members of the Bovid family) seems to have been represented in Pliocene times by *Bos planifrons* and *Bos acutifrons* of the Siwalik deposits of India. Duerst regards *Bos planifrons* † as the ancestor of both *Bos primigenius* and *Bos namadicus*, but Rüttimeyer thinks that though *Bos planifrons* may be ancestral to, it is only a variety of *Bos primigenius*, the European variety of *Bos namadicus*.

Though *Bos primigenius*, like the Bison, only reached Europe in Quaternary times, it was soon widely distributed—its remains occur in English Pleistocene deposits containing *Elephas antiquus* and in deposits of a like age over the greater part of Europe and also in North Africa. While *Bos primigenius* was extending its range over Europe, *Bos namadicus* was spreading over Asia.

It has hitherto been supposed that the Bison was more abundant in Europe during Pleistocene times than the Urus, but Prof. Boule believes that, at least in the vicinity of Grimaldi, the Urus was from the first as common as the Bison.

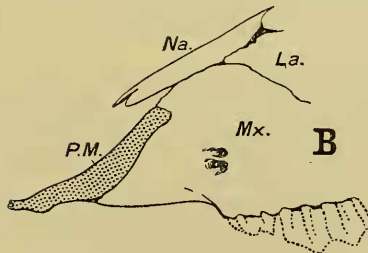
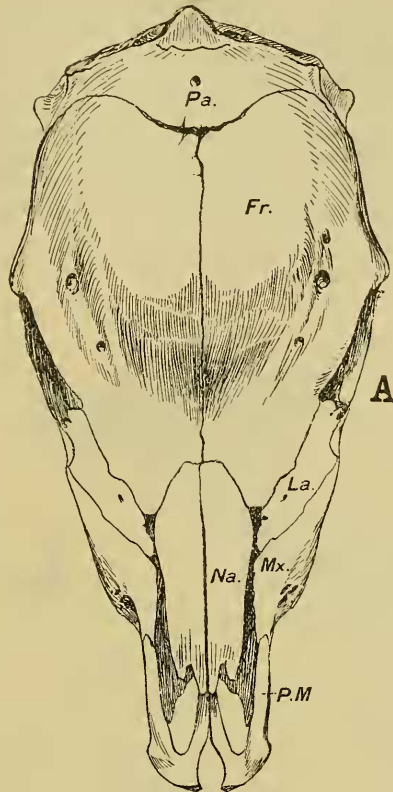
About the colour of the Urus nothing absolutely certain is known, but from drawings of Mediæval, as well as Palæolithic artists we can form a fairly accurate conception of its conformation. A picture, believed to have been made in Bavaria about 1500 A.D., probably brings out the chief points of *Bos primigenius* ‡.

* Duerst, *op. cit.* p. 440.

† According to Duerst's latest view there is no real difference between *Bos planifrons* of Rüttimeyer and *Bos acutifrons* of Lydekker, but at one time he believed *Bos acutifrons* was the predecessor of *Bos namadicus*, to which the Bovine (Gaur and Banting) group and especially the Indian Zebu were related.

‡ This picture is reproduced in the 'Cyclopedia of American Agriculture,' vol. iii. 1900; the Urus apparently survived in Poland up to 1627.

Text-fig. 70.

**A.**—Front view of Calf's skull at birth.

The premaxillæ (*P.M.*) fail to reach the nasals (*Na.*). The parietals and interparietals have coalesced to form a narrow plate (*Pa.*) between the frontals (*Fr.*) and supra-occipital.

B.—Front part of same skull.

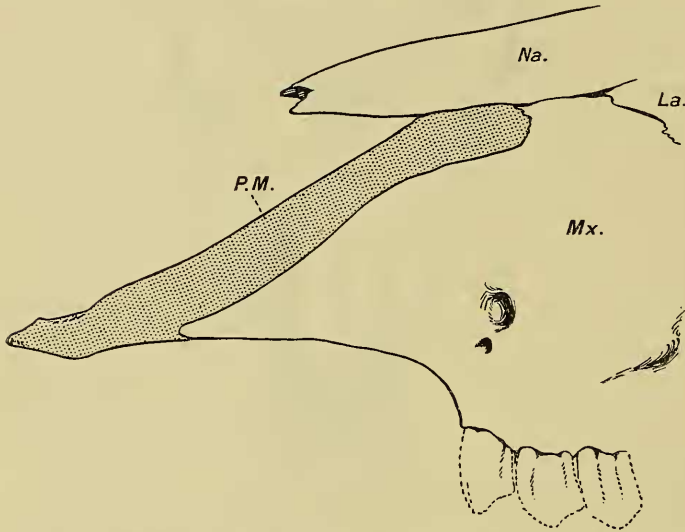
The premaxilla (*P.M.*) is short and some distance from the nasal (*Na.*).

Text-figs. 69 & 70, from specimens belonging to Prof. Charnock Bradley, D.Sc.

The Urus was widely distributed in Britain in Neolithic times, but the examination of Roman and Roman-British stations has hitherto afforded no evidence that *Bos primigenius* still survived in England at the Roman invasion.

A number of more or less complete skulls of the Urus have been found in Scotland, and fragments of skulls, limb-bones, or horn-cores believed to belong to the Urus have been found in almost every county in Scotland between the Solway and the Pentland Firths, and some horn-cores found in Orkney are so large that it is assumed they belong to *Bos primigenius*.

Text-fig. 71.



Front part of skull of a polled Aberdeen-Angus Ox, with premaxillæ (*P.M.*) extending nearly as far up between the maxillæ (*Mx.*) and nasals (*Na.*) as in the Buffalo (text-fig. 64, p. 251). From a specimen in the Royal Scottish Museum.

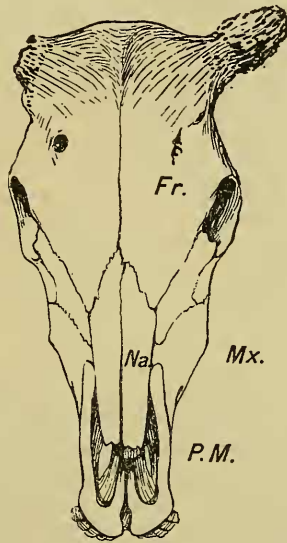
Though there is no evidence that the Urus survived long enough in England to give rise to the Chillingham and other "wild" white park cattle, it has been suggested that a sufficient number survived in the Caledonian forests to found the Cadzow, Atholl, or other Scottish herds of "wild" cattle. The bones from Newstead, however, afford no evidence that the Urus still survived in Scotland when the Romans constructed the border-fort during the later part of the first century A.D.

The skull of *Bos taurus primigenius* is in some respects more highly specialized than that of any other member of the Bovidæ. Hitherto in studying bovine skulls a very considerable amount of attention has usually been directed to the position, size, and

direction of the horns. I shall, however, especially refer to the premaxillæ, occiput, and temporal fossæ.

1. *The Premaxille*.—In some Zebras (*e. g.* the true Burchell Zebra) the premaxilla may only be connected with the nasal for a distance of 12 to 15 mm., while in others (*e. g.* a variety which lives near Lake Baringo) the connection between the nasal and the premaxilla may exceed 50 mm. Differences in the food may account for the premaxillæ being long in some cases and short in others. The premaxillæ may require to be firmly wedged in between the maxillæ and nasals in varieties in the habit of feeding during part of the year on coarse hard food, but only slightly connected with the nasals in varieties which usually consume soft green herbage.

Text-fig. 72.



Skull of a Syrian Ox with vestigial horn-cores and a forehead like that of flat-polled Aberdeen-Angus cattle; the premaxillæ (*P.M.*) as in text-fig. 71 extend far up between the maxillæ (*Mx.*) and nasals (*Na.*). From Wilckens, 'Naturgeschichte der Haustiere.'

In the Anoa (*Bos depressicornis*) of Celebes and in the wild Indian Buffalo (*Bos bubalus*) the premaxillæ are firmly wedged in between the maxillæ and nasals. In the Anoa (text-fig. 63, p. 250) the total length of the premaxilla is 105 mm., and its connection with the nasal is 35 mm.; in the Buffalo (text-fig. 64) the total length of the premaxilla may be 173 mm., and its connection with the nasal 40 mm.

This long intrusion of the premaxilla between the nasal and

maxillary bones doubtless increases the strength of the front part of the jaw which supports the horny pad against which the lower incisors bite. As the Anoa is partial to the neighbourhood of water, it probably feeds on coarse grasses like its ally the Tamarau of the island of Mindoro, which is said to browse on sugar-cane.

The Indian Buffalo lives in the neighbourhood of swamps and jungles, and probably also feeds on reeds and coarse grasses—food which necessitates long, firmly secured premaxillæ.

In the Catalogue of the Ungulata in the British Museum Dr. Gray says that in the true Oxen "the premaxillæ are large and always extend upwards into the triangular space between the maxillæ and the nasals and consequently articulate with both these bones as in *Bubalus*; in the genus *Bibos*, on the other hand, the premaxillæ are small and are attached only to the distal extremity of the maxilla and are separated by a considerable interval from the nasals." As will appear below, the premaxillæ, instead of being always long enough in true Oxen to extend upwards between the maxillæ and nasals as in the Buffalo, are sometimes so short that they fail to reach the nasals as in the Bison (text-fig. 67, p. 253).

In *Bos primigenius* the premaxillæ, in all the skulls I have examined, reach the nasals. In some cases the connection with the nasals is only 5 mm., but in a Urus skull in the British Museum the premaxillæ extend nearly as far upwards between the nasals and the maxillæ as in the Buffalo (text-fig. 64). The extent of the connection between the premaxilla and the nasal in a Urus skull in the Anatomical Museum of the University of Edinburgh is shown in text-figs. 65 & 66.

The premaxilla is shorter and further removed from the nasal in the Bison than in any other member of the *Bos* genus (text-fig. 67). According to Major Heber Percy, the European Bison "are fond of grazing on a coarse aromatic kind of grass known as Zubr grass." Others state that "they are equally fond of browsing on the leaves, young shoots, bark, and twigs of trees," and that "in winter they are driven to subsist entirely on buds, twigs, bark, and such patches of dry grass and fern as remain" *.

The prairie Bison of America apparently fed chiefly on grass, hence doubtless the necessity for the extensive migrations, but the American woodland Bison seem to "subsist chiefly on the leaves and twigs of the birch and willow" †. It is conceivable that owing to the softer nature of the food of the Bison the necessity of having the premaxillæ firmly wedged in between the nasal and maxillary bones no longer exists.

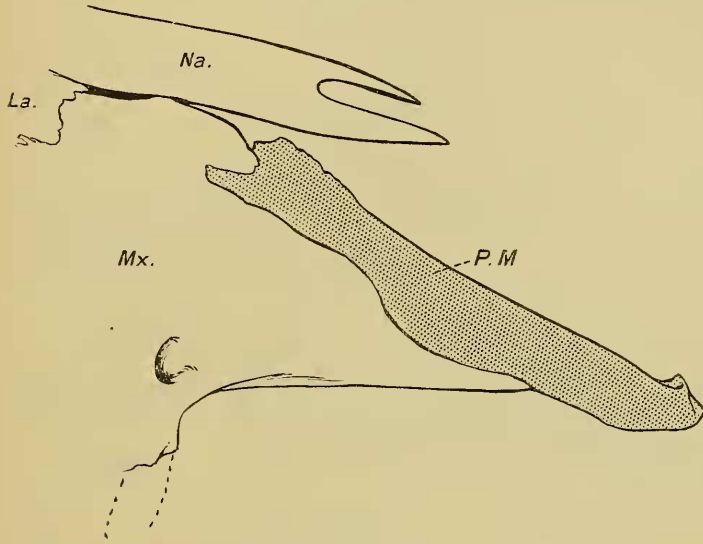
In a very young Domestic Ox skull (breed unknown) the premaxilla (text-fig. 68) bears the same relation to the nasal as in the Urus represented in text-fig. 66; in an older skull it occupies

* Lydekker, 'Wild Oxen, Sheep, and Cattle,' p. 77.

† Lydekker, *op. cit.* p. 91.

the angle between the maxilla and the nasal (text-fig. 69, A, B); but in a skull believed to be that of a new-born calf there is a considerable gap between the premaxilla and the nasal (text-fig. 70, A, B). In some of the skulls from the Newstead Fort the premaxillæ are large and have nearly as extensive a connection with the nasals as in the Buffalo; in others they are short and separated from the nasals by a considerable interval.

Text-fig. 73.



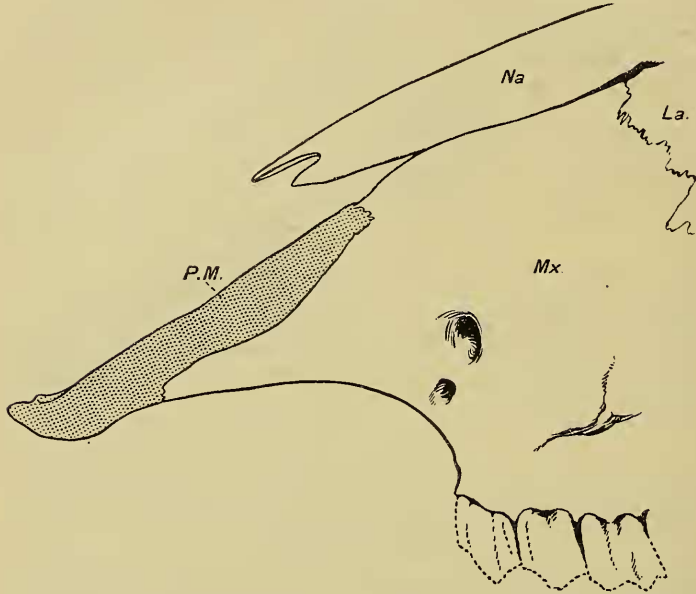
Front part of skull of polled Newstead Ox in which the upper end of the premaxillæ (*P.M.*) bifurcates.

In a Newstead polled skull the premaxillæ are long and more extensively connected with the nasals than in the Urus skull shown in text-fig. 66. In some Aberdeen-Angus cattle the premaxillæ are short, in others they are so long and so extensively connected with the nasals that they reach to within 25 mm. of the lachrymal bones (text-fig. 71); in a Buffalo with premaxillæ of the same length (text-fig. 64) the lachrymals are 75 mm. from the premaxillæ. Apparently in some Syrian cattle the premaxillæ extend well up between the maxillæ and nasals. In a skull of a Syrian Ox figured by Duerst* the premaxillæ bear the same relation to the nasals and lachrymals as in the Angus skull figured. As this Syrian Ox had small imperfect horns (text-fig. 72), and as the skull apart from the horn-cores resembles the skull of the flat-polled Angus strain, it may represent a phase in the evolution of the Aberdeen-Angus breed. The large

* Wilkens, 'Naturgeschichte der Haustiere,' p. 311, 1905.

premaxillæ, coupled with the fact that the parietal extends well on to the forehead, suggest that Aberdeen-Angus cattle have in part sprung from a race domesticated in Central Asia. While in two of the skulls of black polled Aberdeenshire cattle hitherto examined the premaxillæ have an extensive connection with the nasals, in the skull of a white polled "wild" Cadzow Ox as in a black polled Galloway, the premaxillæ bear practically the same relation to the nasals and the lachrymals as in *Bos primigenius*, represented in text-fig. 65.

Text-fig. 74.

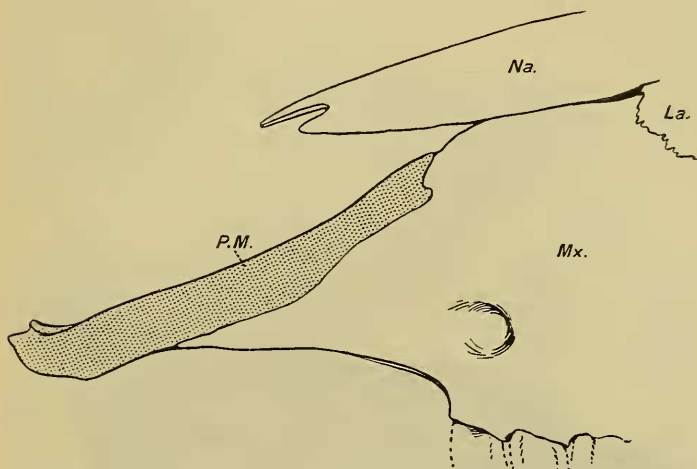


Front part of a horned Newstead skull in which the premaxillæ (*P.M.*) are short and fail to reach the nasals (*Na.*).

In most of the Newstead skulls examined the premaxillæ are absent, but when the maxillæ are present it is usually possible to say whether or not the premaxillæ had reached, or all but reached, the nasals. They probably reached the nasals in at least 90 per cent. of the skulls of the Celtic Shorthorn (*Bos longifrons*) type, and in about 70 per cent. of the skulls belonging to long-horn and cross-bred animals. In the Celtic Shorthorn skulls the premaxillæ, though long and almost in contact with the nasals, instead of ending in a wedge-shaped process, are bifurcated and send a process backwards over the maxilla as well as one upwards between the maxilla and the nasal (text-fig. 73). In having the proximal end forked the Celtic Shorthorn skulls agree with the skull of an

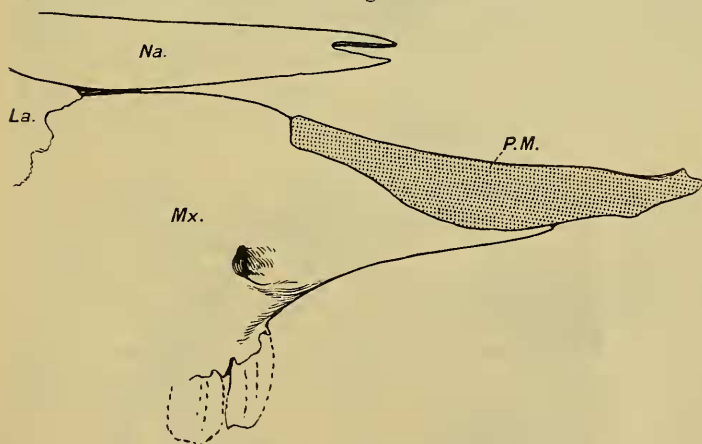
Ox from Irkutsk figured by Duerst*. In cross-bred cattle the premaxilla may be forked on the one side, as in text-fig. 73, but long and rounded on the other as in text-fig. 71.

Text-fig. 75.



Front part of skull of a horned Cadzow Ox with notched premaxillæ (*P.M.*) which fail to reach the nasals (*Na.*). From a skull in the Royal Scottish Museum.

Text-fig. 76.



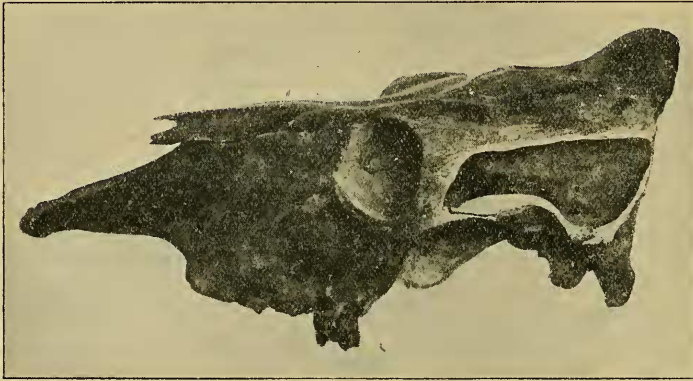
Front part of skull of cross-bred Shorthorn in which the premaxillæ (*P.M.*) fail to reach the nasals (*Na.*).

As already mentioned, Dr. Gray stated in the British Museum

* Wilkens, 'Naturgeschichte der Haustiere,' p. 305, 1905.

Catalogue of the Ungulata that in the true Oxen "the premaxillæ are large and always extend upwards between the maxillæ and nasals and consequently articulate with both these bones as in *Bubalus*." Lydekker, in discussing the premaxillæ in the Bovidæ, points out that in *Bos chinensis*, a new species described by Gray in 1870 (*i. e.* before the publication of the Catalogue of the Ungulates), "the premaxillæ are small and do not extend upwards to the nasals precisely as in *Bibos*"*. But while in *Bos namadicus* and in *Bos chinensis* the premaxillæ may be always small, they are not invariably small in the Bibovine group. In a Gaur skull in the Royal Scottish Museum the premaxillæ reach the nasals, and Mr. Pocock informs me that, of four Gaur skulls he examined

Text-fig. 77.



Skull of polled Newstead Ox with forked premaxillæ, large orbits, deeply notched occiput, uneven forehead ending in a rounded mesial prominence. Skulls of this type with horns are sometimes said to belong to *Bos frontosus* Nilsson.

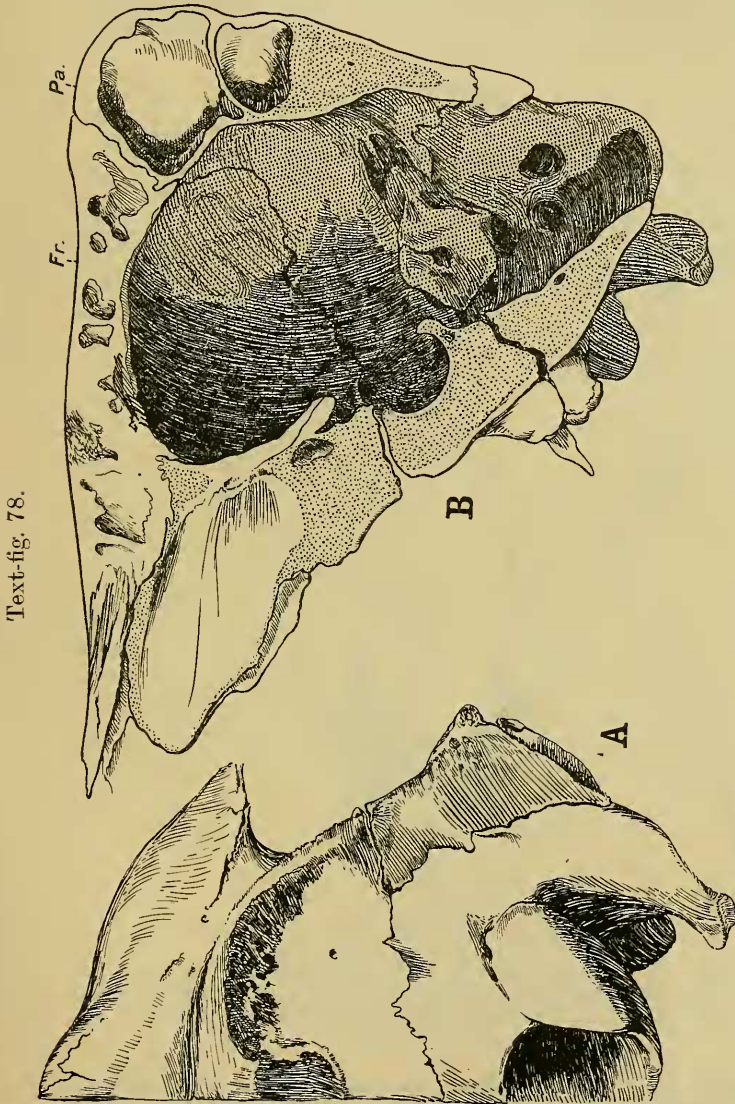
in the British Museum, one has the premaxillæ in contact with the nasals, while in another skull they are separated by a long interval from the nasals. Of all Lydekker's statements about the premaxillæ, the one which bears most on the present enquiry is to the effect that a small premaxilla is "*never found in any European Ox*" †. If the premaxilla is small in *Bos namadicus*, but never small in European cattle, the presumption is that European cattle are not descended from *Bos namadicus*, but from *Bos primigenius*, in which the premaxillæ in all the skulls examined reach the nasals.

In one of the Newstead skulls, which probably belongs to an imported Ox, as large as a modern Aberdeen-Angus steer, the total length of the premaxilla is only 118 mm.—47mm. shorter than the

* Memoirs of the Geological Survey of India, series x. vol. i. p. 19.

† *Op. cit.* p. 3.

premaxilla of the Aberdeen-Angus heifer represented in text-fig. 71. The distance between the premaxilla and the lachrymal in this Newstead Ox is 80 mm., in the Aberdeen-Angus only 25 mm.



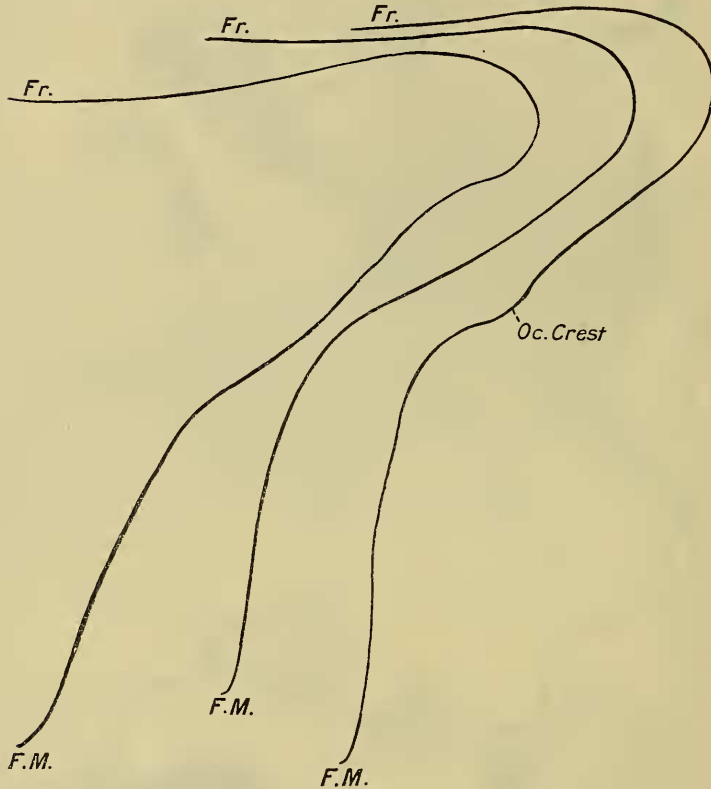
A.—Right half of occiput of the Aberdeen-Angus skull with long premaxillae (text-fig. 71, p. 258). It shows the sutures between the supra-occipital, ex-occipital, and temporal bones; and parts of the suture between the parietal and frontal.

B.—Section of A. The interparietal (*Pa.*) extends forwards between the frontals to form part of the forehead. The frontal sinus communicates with a large sinus in the parietal, below which is a sinus in the supra-occipital. In this skull the occiput forms a nearly right angle with the forehead. From a skull in the Royal Scottish Museum.

But in addition to being small, or rather because it is small, it fails to reach the nasal and makes no attempt to fill up the gap between

the maxilla and the nasal (text-fig. 74). As it happens, there is a skull of one of the so-called "wild" white Cadzow cattle from Hamilton Park in the Royal Scottish Museum which probably belonged to an Ox including the Celtic Shorthorn amongst its ancestors. In this Ox (text-fig. 75), though the premaxilla is 142mm. in length it neither reaches the nasal nor yet extends into the gap

Text-fig. 79.



Outlines of the occiput and part of the forehead of three Urus skulls.

Fr., frontal: *F.M.*, upper border of *foramen magnum*.

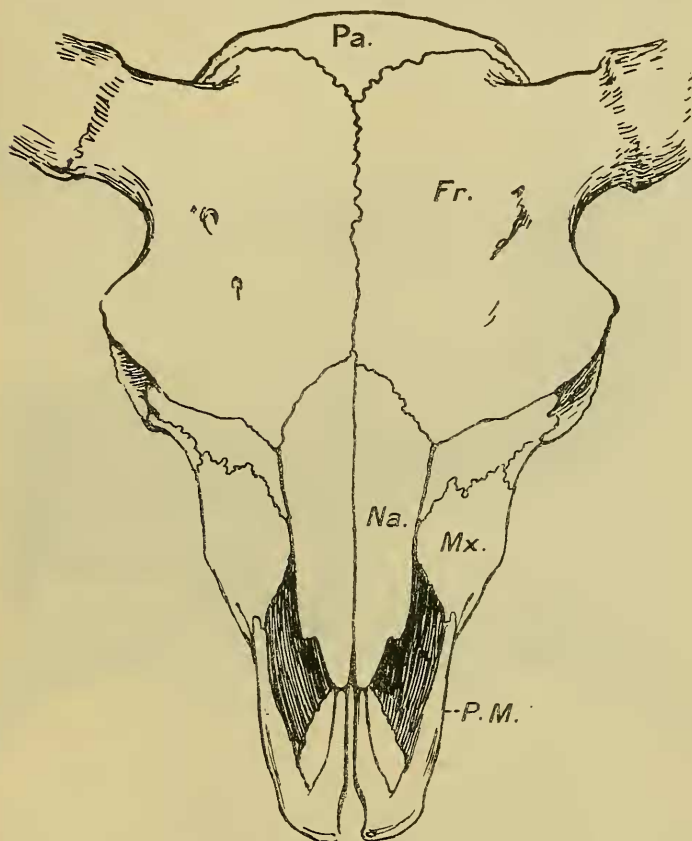
In all three skulls the intercornual ridge projects far beyond occipital condyles.

From skulls in the Anatomical, Antiquarian, and Free Church College
Museums, Edinburgh.

between the maxilla and nasal. In shape and in being notched at its proximal end, it reminds one of the premaxilla of the Celtic Shorthorn (text-fig. 73). Another skull with premaxillæ which fail to reach the nasals may be mentioned, because it has many of the

characteristics of the Urus. In this skull (text-fig. 76), which belonged to a cross-bred Shorthorn, the premaxilla in shape closely agrees with the premaxilla of the Urus, but it is relatively shorter and neither reaches the nasal nor extends into the space between the nasal and the maxilla.

Text-fig. 80.

Front view of skull of Bison (*Bos bison*).

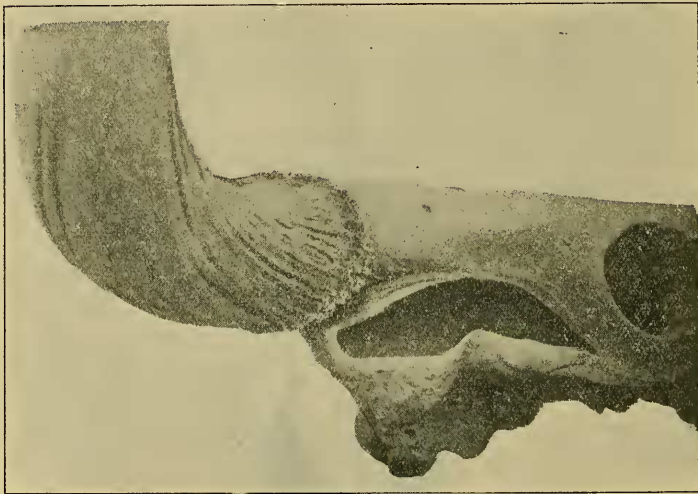
In the Bison the horn-cores are near the orbits, the parietals (*Pa.*) are not overlapped by the frontals (*Fr.*), and the premaxillæ (*P.M.*) are far removed from the nasals (*Na.*).

Though very few skulls have been available for study, it is evident (1) that in some modern European cattle as well as in some of the cattle in Britain during the Roman occupation, the premaxillæ were short and failed to reach the nasals, and (2) that as

the premaxilla vary in wild as well as in domestic cattle the relation of the premaxilla to the nasals is of little diagnostic value.

The Forehead.—In the Newstead skulls the forehead varies considerably; in some specimens it is flattened as in a typical Urus (text-fig. 66), and the ridge between the horn-cores is nearly straight; in others there are prominences and depressions and the intercornual ridge is arcuated as in some specimens of the Urus, while in a polled skull (text-fig. 77) of the *frontosus* type, the vertex projects forwards and upwards to form a well-marked rounded mesial prominence. In this polled skull there is also a projection from the middle of the forehead and a well-marked ridge at each

Text-fig. 81.



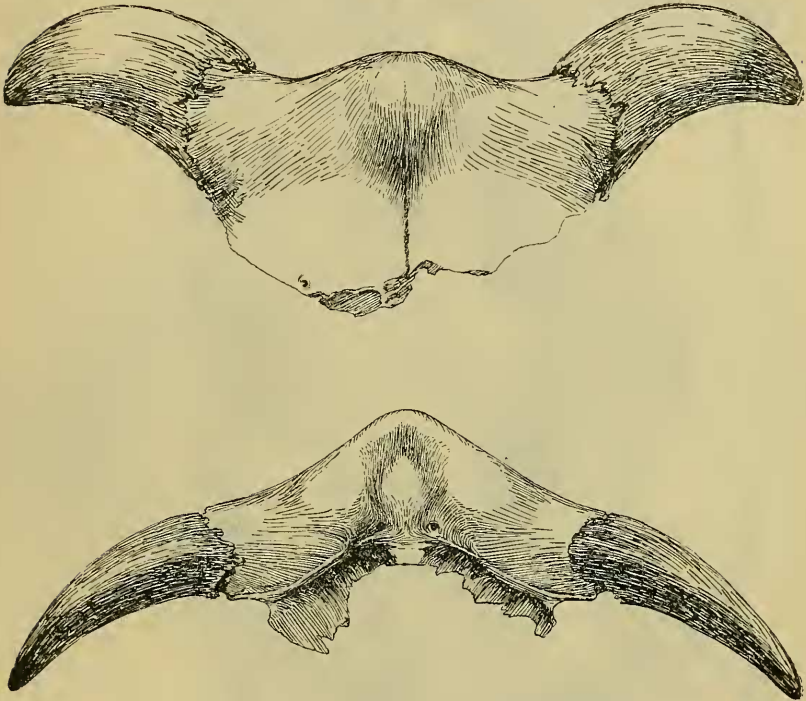
Hind part of skull of the Urus represented in text-fig. 66.

The front of the horn-core is in a line with the occipital condyle, and the temporal fossa is closed behind by a plate of bone which supports the horn-core.

side between the orbit and the long deep orbital sulcus. In old animals the parietals seem to be completely covered by the frontals. But even when the intercornual ridge projects far beyond the level of the occipital condyles the interparietal probably enters into the formation of the forehead. That the parietals (or the interparietals) form part of the forehead in polled Oxen is indicated by text-fig. 78 B, *Pa.* That in horned Oxen the parietals also enter into the formation of the forehead is suggested by a large skull of the Urus type in the Royal College of Surgeons Museum, London (No. 1121 A). In this skull the frontals are separated by a wedge-shaped piece of bone (probably the inter-

parietal), which forms the middle portion of the intercornual ridge. Oscar Schmidt* states that in a front view the parietals "cannot be seen at all," but probably in all cases the parietals in the Ox, as in the Bison (text-fig. 80), enter into the formation of the forehead. The great specialization of the frontal region of the skull in the true Oxen is made evident by the examination of foetal skulls. In a very young foetus the frontals (text-fig. 68, *Fr.*) only form the front portion of the roof of the cranium; but about

Text-fig. 82.



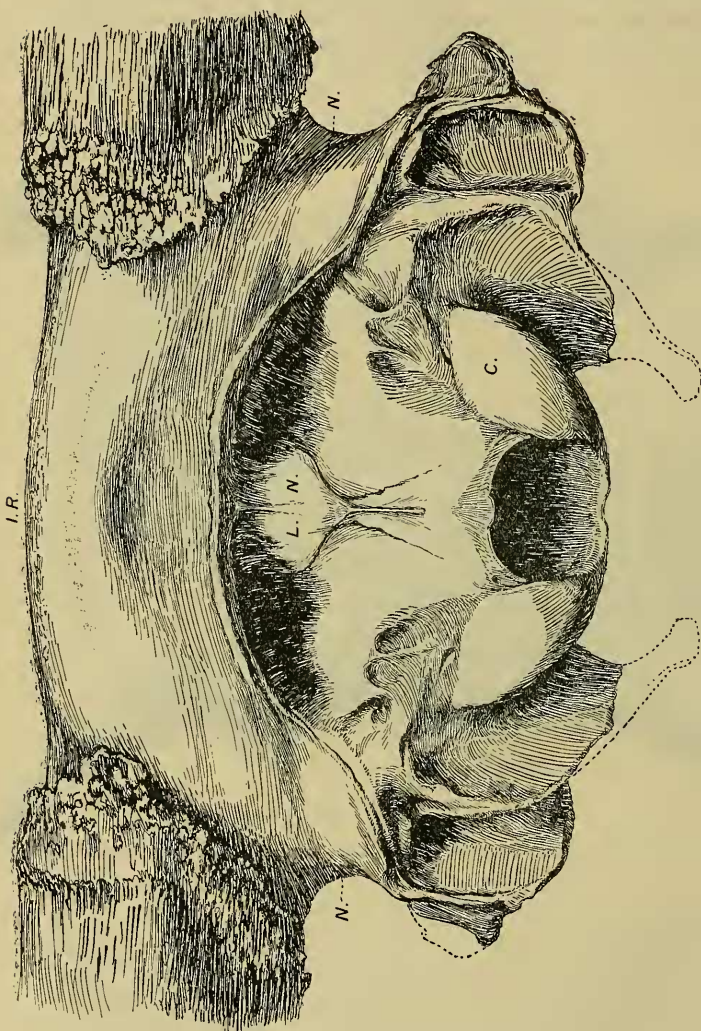
Frontlet and horn-cores of a small Newstead Ox with a prominent forehead.
The horn-cores curve upwards and backwards.

the fifth month they are relatively very much larger than the parietals (text-fig. 69, *Fr.*), and at birth they form nearly the entire roof of the cranium (text-fig. 70). After birth the frontals continue to grow backwards, and they eventually form all but the wedge-shaped middle portion of the intercornual ridge. In the Urus the frontals sometimes project 100 mm. (4 inches) beyond the occipital condyles (text-fig. 79), but in the Aberdeen-Angus the occiput almost forms a right angle with the frontals, and the

* 'The Mammalia,' p. 176.

parietals (text-fig. 78 B), as in the Bison (text-fig. 80), obviously enter into the formation of the forehead. The highly specialized condition of the occiput in the Urus has resulted from the horns having migrated upwards from their original position above the

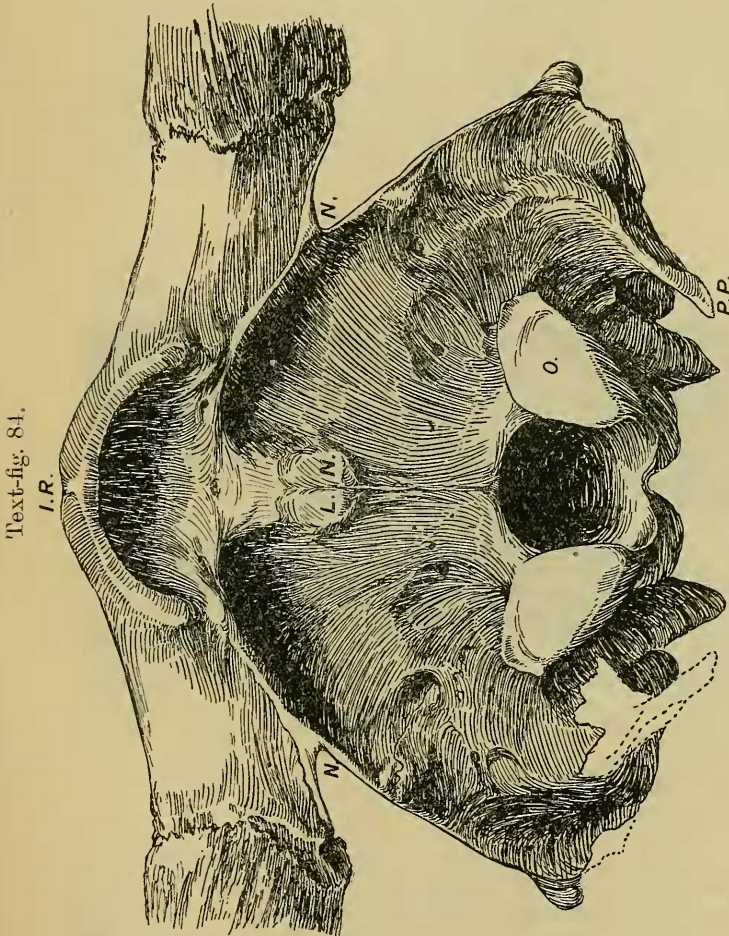
Text-fig. 83.



Occiput of Urus skull represented in text-figs. 66, 79 (outline showing occipital crest, *Oc. Crest.*), and 81. The occiput is quadrangular, the occipital crest flattened, and the notches (*N.*) between the crest and horn-cores are shallow; *C.*, occipital condyle; *L.N.*, shield for attachment of *Ligamentum nuchae*; *I.R.*, intercornual ridge. The occiput is completely cut off from the temporal fossa.

orbits (text-fig. 63) to lie entirely behind a line passing through the occipital condyles (text-fig. 81). In addition to Newstead skulls with the forehead flat or presenting ridges or prominences, there is a skull (text-fig. 82) in which the forehead is so convex that the

horn-cores at their origin are far behind the most prominent part of the forehead. Moreover, the horn-cores in this case are flattened and curve outwards and backwards as in some Eastern cattle. In their position and direction the horns in this Newstead Ox decidedly differ from the horns (also of the flat type) of a Shetland heifer in my possession, which project almost directly upwards as in some Zebus.



Occiput of the Newstead skull represented in text-fig. 86, p. 271.

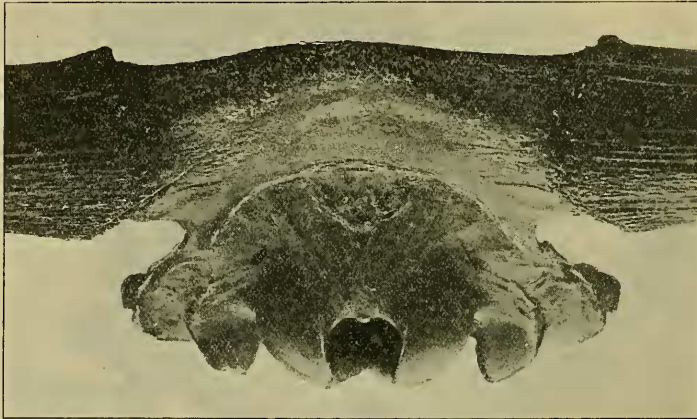
The occipital crest is rounded, and deep notches (N.) separate the supra-occipital from the horn-cores. A deep semilunar depression occupies the middle of the intercornual ridge immediately above the occipital crest; O., occipital condyle; P.P., paroccipital process; L.N., surface for attachment of *Ligamentum nuchae*; I.R., mesial frontal prominence.

The horn-cores are, as a rule, circular in section and, in skulls of the Celtic Shorthorn type, curve outwards and forwards nearly at a right angle to the frontals. In other skulls they curve outwards and upwards, or outwards and downwards, or outwards,

upwards, and backwards as in some Indian cattle. Except when they curve forwards at right angles to the frontals, as in typical Celtic Shorthorns, the horns assist but little in settling the race to which the Newstead skulls belong.

The Occiput.—In some Newstead skulls the occiput has the characteristics of the Urus represented in text-fig. 83. The general outline is quadrangular, the occipital crest is flattened but not encroached on by the temporal fossæ, the lateral borders are nearly straight, and a line carried through the highest point of the crest lies below the centre of the horn-cores; further, there is a shield-like projection (*L.N.*) for the insertion of the ligamentum nuchæ. The distance from the crest to the lower border of the foramen magnum is nearly the same as the distance between the condyles (*C.*) and little more than half the distance between the notches (*N.N.*) below the horn-cores on a level with the temporal fossæ.

Text-fig. 85.



Occiput and horn-cores of a Urus in which the notches below the horn-cores are deeper than in text-fig. 83.

This occiput closely resembles the occiput of a *Bos namadicus* skull in the British Museum.

The nearly smooth supracristal part of the occiput extending between the horn-cores measures from above downwards about half as much as the part lying between the crest and the lower border of the *foramen magnum*. In some cases the supracristal part is flat and nearly in a line with the occiput proper, in others it projects beyond the crest (text-fig. 79) and, though concave in the centre immediately over the shield for the ligamentum nuchæ, it is prominent and convex above and forms a marked angle with the forehead. In some cases the upper border of the

occiput viewed from behind is nearly straight, in others it is slightly concave or distinctly arcuated.

In specimens of the Urus with very thick horn-cores a bridge of bone extends downwards from the base of the horn-core and forms a posterior wall for the temporal fossa (text-figs. 81 & 83, *N.*), which completely cuts off the fossa from the occiput. It is owing to the temporal fossæ being closed in behind by extra supports for the horn-cores that the width of the occiput immediately below the horn-cores is sometimes nearly twice as much as the distance between the crest and the lower border of the *foramen magnum*.

Though in the majority of the Newstead skulls the occiput conforms to the Urus type there are several with short premaxilla in which the occiput reminds one of Lydekker's *Bos acutifrons*. Writing in 1880 Lydekker pointed out that *Bos acutifrons* of the Punjab Siwaliks had no marked relationship to any existing species and was "widely different in the form of its occiput, frontals, and horn-cores from *Bos primigenius*"*.

Though Rüttimeyer and others regarded *Bos planifrons* and *Bos acutifrons* as varieties of a species closely allied to *Bos primigenius*, no skulls of true Oxen have hitherto been described in which the occiput resembles that of *Bos acutifrons*.

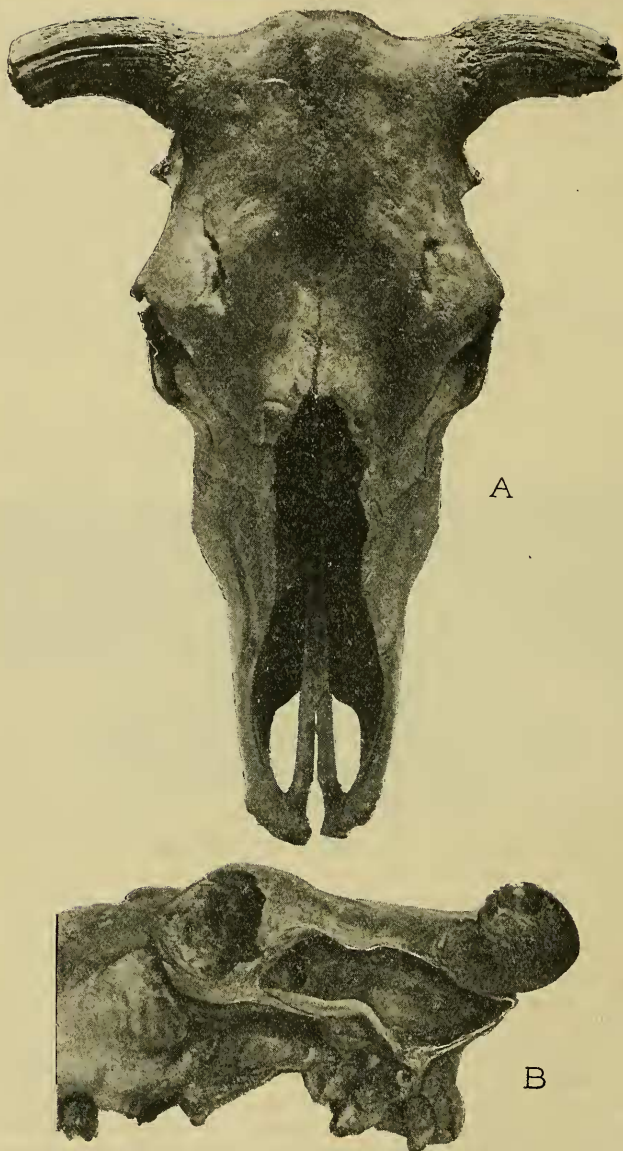
In *Bos namadicus*, as well as in *Bos primigenius*, the notches below the bases of the horn-cores are shallow, but in the Newstead skull represented in text-fig. 84 indentations or notches (*N.*) below the horn-cores are so deep that the connection between the upper (parieto-frontal) part of the occiput and the lower (infracristal) part is relatively short. Because of these indentations the occiput viewed from behind (text-fig. 84) bears a resemblance to that of the Gaur (*Bos gaurus*).

In *Bos primigenius* the summit of the occipital crest is on a lower level than the middle of the horn-cores (text-fig. 83), but in the Newstead skull of the *acutifrons* type a line carried through the summit of the rounded arch formed by the occipital crest (text-fig. 84) passes above the middle of the horn-cores.

At the widest part the occiput of the first century skull (text-fig. 84) measures 215 mm., and from the lower border of the *foramen magnum* to the occipital crest the distance is 115 mm. The depth (115) multiplied by 100 and divided by the width (215) gives an index of 53·5. In the Urus represented in text-fig. 85 the corresponding index is 47. Between the notches under the horn-cores the distance in the Newstead skull (text-fig. 84) is 123 mm.: $123 \times 100 \div 215$ (the total width of occiput) gives an index of 57; in the Urus, owing to the shallowness of the notches under the horn-cores, the corresponding index may be 90. The distance (115 mm.) between the lower border of the *foramen magnum* and the occipital crest multiplied by 100 and divided by the distance (123 mm.) between the infracornual notches gives an index of 93·5; the corresponding index in the Urus may be only 52·4.

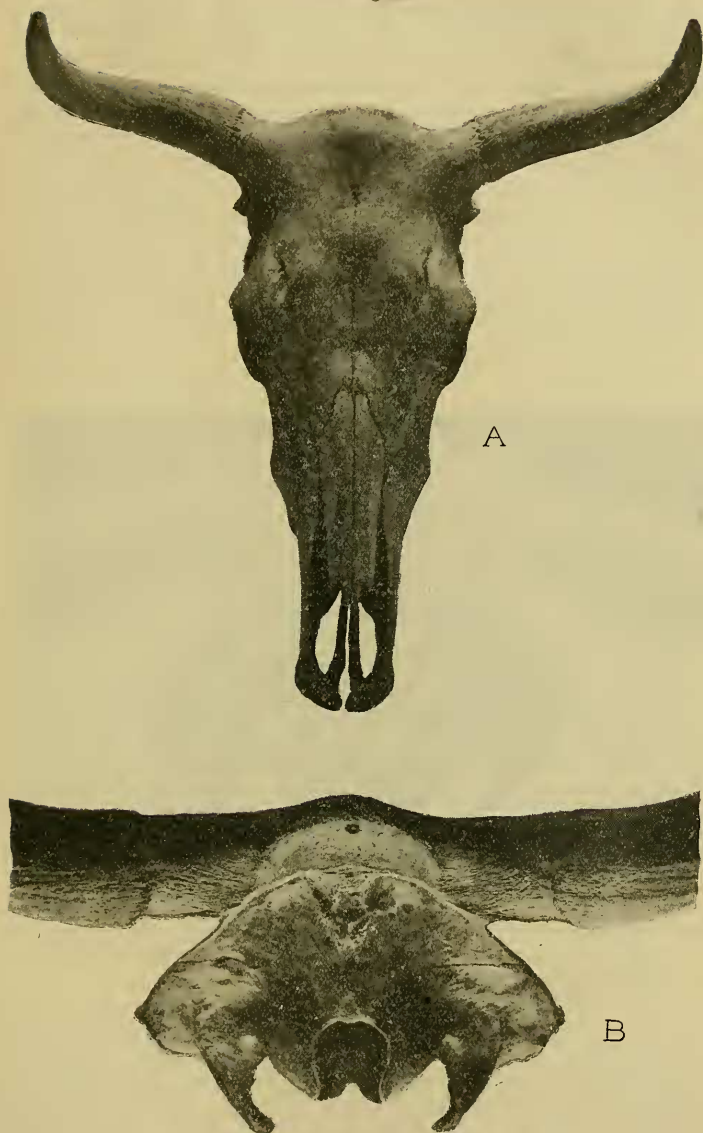
* Memoirs of the Geological Survey of India, series x. vol. i. p. 2.

Text-fig. 86.



- A.**—Front view of the Newstead skull of which the occiput is represented in text-fig. 84, p. 271.
- B.**—Temporal fossa of above skull. The fossa communicates freely with the occiput. Compare with fossa of the Urus (text-fig. 81, p. 268).

Text-fig. 87.



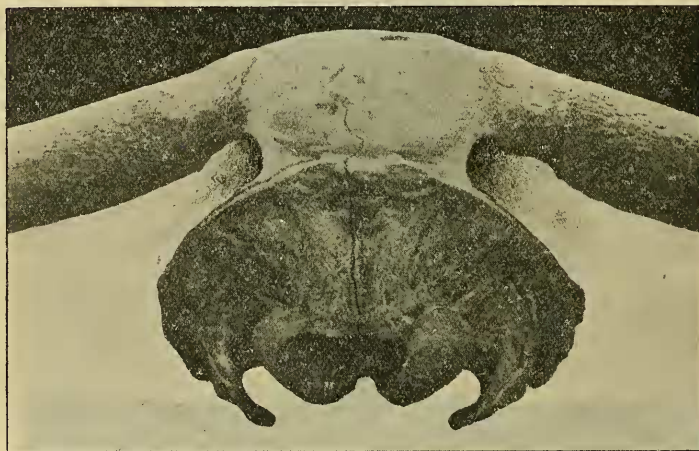
A.—Front view of a white "wild" Cadzow Ox from Hamilton Park.

B.—Occiput and horn-cores of the above skull.

This skull closely resembles the Newstead skull (text-figs. 84 & 86) with a deeply notched occiput. From a specimen in the Royal Scottish Museum.

From the narrow shield-shaped projection (*L.N.*) under the crest (text-fig. 84), a narrow ridge extending towards the *foramen magnum* divides the lower part of the occiput into two equal portions roughened for the attachment of muscles. Between the crest and the upper border of the *foramen magnum* the occiput is distinctly concave—near the crest it is excavated to a depth of 12 mm. The part of the occiput external to the condyles (*C.*) is divided by a ridge continuous with the incurved paroccipital processes (*P.P.*) into two irregular, more or less concave, rough surfaces. The greatest width across the occipital condyles (*C.*), is 99 mm. (only 23 mm. less than the space between the infracornual notches): $99 \times 100 \div 123$ (the width of the occiput under the horn-cores) gives an index of 80. The corresponding index in the Urus skull (text-fig. 83) is only 55.

Text-fig. 88.



Occiput and horn-cores of an American Bison.

The frontals neither cover the parietals (text-fig. 80, p. 267) nor project beyond the level of the occipital crest, and the horn-cores are separated by wide gaps from the supra-occipital.

The part of the occiput above the occipital crest is divided into three portions, viz. :—a mesial semicircular deeply excavated portion and two lateral portions continuous with the horn-cores externally and the forehead above. The mesial semicircular concave portion (text-fig. 84), 60 mm. wide and 20 mm. deep, has a rough margin, 3 to 6 mm. in thickness, which forms the nearly horizontal border of the mesial frontal protuberance (text-fig. 86, A).

From the measurements given it follows that the occiput of

the Newstead skull (text-fig. 84) differs profoundly from that of the more highly specialized Urus skull represented in text-fig. 83.

The Horn-cores.—The horn-cores of the Newstead skull, characterized by a deeply notched occiput, are pyriform as in *Bos acutifrons*—they measure at their origin 60 mm. from above downwards and 45 mm. from before backwards. At a distance of 30 mm. from the beginning of the grooved surface they measure 56 mm. by 42 mm. The fragments of the horn-cores present (text-fig. 86, A) are convex above, grooved in front and below, and extend outwards and slightly forwards.

The Temporal Fossa.—In the Urus skull figured the temporal fossa is completely closed behind (text-fig. 81) by a wall of bone which helps to support the horn-core (text-fig. 83); the external opening of the fossa, rounded and contracted behind, is pointed in front and arched above (text-fig. 81). In the Newstead skull with short premaxillæ and a notched occiput, the temporal fossa is wide behind, where it opens on to the occiput, wider than in the Urus in front, and the upper border is sinuous (text-fig. 86, B) as in the Bison.

The Base of the Cranium.—In the Urus the anterior as well as the posterior tubercles are well developed, but in the Newstead skull (text-fig. 84), as in *Bos acutifrons*, the anterior tubercles are small and inconspicuous.

In having the lower part of the occiput separated from the upper by deep notches under the horn-cores the Newstead skull (text-fig. 84) decidedly differs from *Bos primigenius* (text-fig. 83) and also, though to a less extent, from *Bos namadicus*. Again, in having the occipital crest overhanging the true occiput, the Newstead skull differs from the Gaur and Banting.

If Lydekker is right in assuming that the occipital crest in *Bos acutifrons* "extends upwards to within a short distance of the *vertex cranii* so that the supra-cristal portion of the occipital region is reduced to a very narrow band"*, the Newstead skull also differs from *Bos acutifrons*. If, however, in *Bos acutifrons* the mesial depression immediately below the vertex is supra-cristal, the Newstead skull with a deeply notched occiput may be regarded as belonging to a race allied to, or descended from, *Bos acutifrons* of the Punjab Siwaliks.

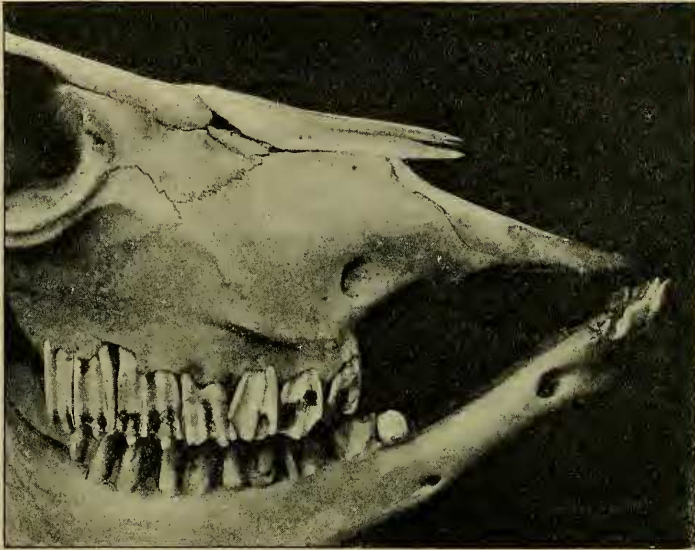
It will doubtless be asked, Are any of the modern breeds of cattle characterized by short premaxillæ and an occiput of the primitive type represented in text-fig. 84? As it happens, the skull (text-fig. 87) of the white "wild" Cadzow Ox with short premaxillæ (text-fig. 75) has an occiput (text-fig. 87, B) of the *acutifrons* type, and otherwise resembles several of the Newstead skulls. The skull of the Cadzow Ox seen from behind looks almost as if it were intermediate between the Bison (text-fig. 88) and a Urus with fairly deep notches (text-fig. 85).

At one time the Hamilton Park herd of white cattle consisted

* Memoirs of the Geological Survey of India, ser. x. vol. i. p. 27.

almost entirely of polled individuals, now they are said to be all horned *. There is a tradition that Cadzow cattle re-acquired horns through a Highland bull, which, for a time, took forcible possession of the herd, and it is a matter of history that some years ago a "wild" Chillingham bull was made use of to reinvigorate the Cadzow "wild" cattle. The intercrossing, perhaps, led to reversion towards a race in the possession of, if not actually introduced by, the Roman auxiliaries who garrisoned the border-fort during the later part of the first century †.

Text-fig. 89.



Front part of the skull of a Zebu (*Bos indicus*) in which the premaxillæ reach the nasals.

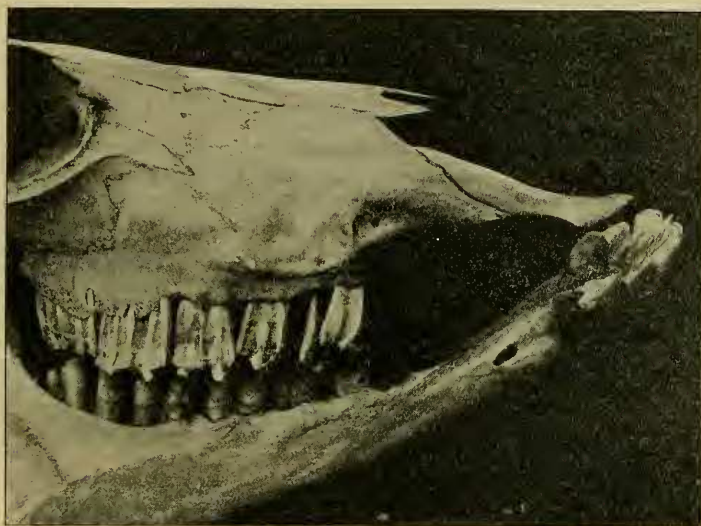
In addition to Newstead skulls with an occiput of the Urus and *acutifrons* types, there are skulls which in the occiput agree with certain Indian cattle. In Indian as in European domestic cattle the premaxillæ are sometimes long and in contact with the nasals (text-fig. 89), sometimes short and terminating some distance from the nasals (text-fig. 90). In at least some Zebus long premaxillæ are correlated with a wide Urus-like occiput, and short premaxillæ with a narrow deep occiput. In several small Newstead skulls the occiput closely

* A skull of a polled Cadzow Ox in the Anatomical Museum of the University of Edinburgh agrees in the premaxillæ and occiput with *Bos primigenius*.

† The Chillingham and Chartley "wild" park cattle in their occiput conform to the Urus type.

agrees with a Zebu skull (text-fig. 91) in the Royal College of Surgeons Museum, London. In *Bos primigenius* the shield-like projection for the *ligamentum nuchæ* is in contact with the occipital crest, but in some of the small Newstead skulls, as in the skull of the *acutifrons* type, the rough surface for the attachment of the *ligamentum nuchæ* lies, as in some Zebus, nearly midway between the occipital crest and the upper border of the *foramen magnum*. Further inquiry may show that Indian domestic cattle are in part descended from ancestors allied to Lydekker's *Bos acutifrons* and that the Celtic Shorthorn (*Bos longifrons* Owen, *Bos brachyceros* Rüttimeyer) is intimately related to some of the small Oriental races.

Text-fig. 90.



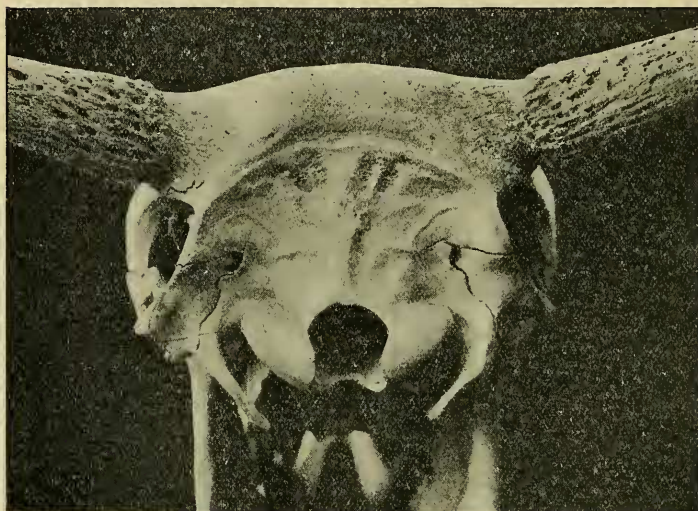
Front part of the skull of a Zebu in which the premaxillæ fail to reach the nasals.

The Origin of the Newstead Oxen.

In addition to cross-bred animals Newstead has yielded five fairly distinct types of Oxen, viz.:—(1) Oxen of the Celtic Shorthorn type; (2) Long-horned Oxen of the Urus type; (3) Oxen with an occiput of the *Bos acutifrons* type; (4) Oxen with a convex forehead, an arcuated intercornual ridge and horns curving outwards and backwards; and (5) Hornless Oxen. It is impossible to say definitely how any of these forms originated, but it may be safely assumed that they were not all formed in Europe from *Bos primigenius*.

Though *Bos primigenius* reached Europe from Central Asia in early Pleistocene times, there is no evidence that it was living under domestication on the arrival in Post-Pleistocene times of the Neoliths. Further, there is no evidence of the existence of a small Ox of the Celtic Shorthorn type in European Palaeolithic deposits—Prof. Boule *e. g.*, found not a single fragment of Owen's *Bos longifrons* in deposits of the Reindeer age at Monaco. Neither is there any evidence of the existence of a small wild Ox in Pleistocene times in Central Asia.

Text-fig. 91.



Occiput of the Zebu with the premaxilla reaching the nasals (text-fig. 89).

In several of the Celtic Shorthorn skulls from Newstead the occiput resembles that of the Zebu.

Text-figs. 89-91 from skulls in the Royal College of Surgeons Museum, London.

The examination of the bones of Oxen from Anau, Turkestan, led Duerst to conclude:—(1) that a large long-horned breed was formed by the Anau-li about 8000 B.C. from a large wild Asiatic race which he regarded as the exact equivalent of the European Urus (*Bos primigenius*); (2) that about 6000 B.C. a small short-horned breed, identical with Owen's *Bos longifrons* and Rüttemeyer's *Bos brachyceros*, was formed at Anau, or brought to Anau from some other settlement in Central Asia. If, as seems probable, the Urus was the only wild Ox in Central Asia in prehistoric times, it must be assumed that the small Ox in the

possession of the Anau-li was a dwarfed descendant of an Asiatic variety of *Bos primigenius**.

It is doubtless possible that a small breed may have been formed out of the huge Urus by the Neoliths immediately after they reached Europe, but the evidence, so far as it goes, suggests that the Neoliths brought the "Celtic" Shorthorn with them from Central Asia.

Though in Britain the Urus was hunted by the Neoliths—evidence of this we have in the Urus skull from Burwell Fen, near Cambridge, with the frontals pierced by a Neolithic flint implement—there is no evidence that *Bos primigenius* was once domesticated in Britain or that the Neoliths allowed their domestic cattle to breed with young wild bulls.

But on the Continent the Urus was apparently domesticated at a comparatively early period and crossed with the small breed originally brought from Central Asia. Hence it may be said that up to at least the Bronze age the majority of the domestic cattle in Europe were the descendants of *Bos primigenius*—some being nearly pure descendants of the imported "Celtic" Shorthorn breed, while others were pure or nearly pure descendants of the indigenous wild Urus (*Bos taurus primigenius*).

There is no evidence that there existed in Europe or in Central Asia a variety of *Bos primigenius* with the occiput deeply notched and otherwise resembling the one represented in text-fig. 84. Neither is there any evidence that in *Bos namadicus*—the Urus of India—the occiput was deeply notched or characterized by an excavated intercornual ridge. The only extinct form to which the Newstead skull represented in text-figs. 84 and 86 bears any marked resemblance is *Bos acutifrons* of the Pliocene Siwaliks. It has been suggested that the Newstead skull with a deep mesial semicircular depression above the occipital crest belonged to a hybrid between an Ox and a Bison, but this view is not supported by the skulls of Ox-Bison hybrids. Moreover, in its occiput and premaxillæ this Newstead skull (text-figs. 84 & 86) very closely agrees with the skull of a Cadzow Ox (text-fig. 87) in the Royal Scottish Museum. It may hence in the meantime be assumed that some of the cattle in the south of Scotland during the Roman occupation were descended from an Indian race allied to *Bos acutifrons*.

Of the Newstead cattle with horns curving backwards and downwards (text-fig. 82) it need only be said that they seem to be more intimately related to *Bos namadicus* than to *Bos primigenius*.

The polled Newstead cattle represent two distinct types. Some had a nearly flat forehead, a nearly straight "intercornual" ridge, and a square-shaped occiput; in others the forehead was very uneven and ended in a pronounced mesial prominence which projected upwards and forwards (text-fig. 77). The Newstead

* The small Ox of Anau is probably now represented in Asia by the long-browed Zebus characterized by small horns of the *Bos longifrons* type.

cattle with a flat poll (as in the modern Galloway and in polled Cadzow cattle) obviously belong to the Urus type, while those with a mesial prominence seem to belong to the *frontosus* type of Nilsson. As there were hornless cattle in Egypt as early as the Fourth Dynasty, we are not likely soon to ascertain where or when polled breeds originated. There is no evidence that any of the varieties of polled cattle are descended from hornless wild ancestors; neither is there certain evidence of a pure horned race suddenly producing polled offspring. If, as seems highly probable, the absence of horns is not due to reversion, the polled condition was either acquired by the gradual reduction in the size of the horns or suddenly, *i. e.* by mutation. In polled breeds which now and then produce individuals with "loose horns" the polled condition was perhaps acquired slowly, while in polled breeds in which "scurrs" are unknown the polled condition was perhaps due to a mutation. Though the Galloway and the white polled "wild" Cadzow cattle may have descended from *Bos primigenius*, the white polled Somerford, and the round polled Aberdeen-Angus cattle with the premaxillæ extending well up between the maxillæ and nasals, may be the descendants of an Oriental race allied to a modern Syrian breed apparently in the act of losing the horns.

13. Plankton from Christmas Island, Indian Ocean.—I. On Copepoda of the Family *Coryceidae*. By GEORGE P. FARRAN*.

[Received October 31, 1910: Read February 7, 1911.]

(Plates X.—XIV. †)

Through the kindness of Dr. W. T. Calman I have had the opportunity of examining the Copepoda of a small collection (8 bottles) of Plankton, made by Sir John Murray, K.C.B., F.R.S., and Dr. C. W. Andrews, F.R.S., at Christmas Island in the Indian Ocean, and presented to the British Museum by Sir J. Murray.

The gatherings were all made at approximately the same time (July–August, 1908) and in the same locality, on the north side of the island in shallow water near shore, and for this reason it has not been thought necessary to refer to each of them separately.

The collection, though small in bulk, is exceedingly rich in species, and the genus *Coryceus* is especially well represented.

It has been recognized that there are, in the the genus *Coryceus*, two groups differing from each other in several distinct characters, the most notable being the form of the ventral process, situated between the maxillipedes and the first pair of

* Communicated by Dr. W. T. CALMAN, F.Z.S.

† For explanation of the Plates see p. 296.